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These views of Chanet, more than two centuries old, are both interesting and important. They illustrate the truth of the maxim, that "there is nothing new under the sun;" and demonstrate, if any such proof were needed, that the theory of the localisation of the functions of the brain is not a new discovery. It is, however, of less importance to the student of science to know whether it be new provided it be true.

There is a manifest disadvantage in treating a subject like the present in detached portions. Although, however, it has its drawbacks, it is really at present the only practical way of at all successfully treating the subject in hand. The question of the localisation of brain function is growing from day to day; for no sooner is a work published giving the latest results, than it seems out of date. I purpose, in this series of articles, to give a general sketch of the whole subject, with a digest of the present state of the controversy respecting the localisation of one of the mental faculties; and we shall then be better able to continue to give, from time to time, new facts that may be acquired either for or against this important theory.

[*To be continued.*]

ON THE MEASUREMENT OF CRANIA.*

By Jeffries Wyman, M.D., Hersey Professor of Anatomy in Harvard College, and Curator of the Peabody Museum of Archæology and Ethnography; Corresponding Member of the Anthrop. Society of London.

Tiedemann appears to have been the first to attempt anything like an extensive comparison of human crania based upon their capacity.† To this end, 1, he weighed the skull without the lower jaw; 2, filled the skull with dried millet seed and weighed again; 3, deducting the weight of the skull he obtained the weight of the millet seed filling it. Thus a means for determining the comparative size of the cranial cavity in different individuals or races was obtained, but it failed to give any exact idea of the volume of the brain. The method proposed by Sir William Hamilton was more successful; he filled the cranium with fine sand which was measured in cubic inches; having determined the weight of a cubic inch of sand, he multiplied this by the number of cubic inches contained in the skull, and making a correction for the difference in the specific gravities of brain and sand, the weight of the brain was approximately reached.* Prof. D. Treadwell has proposed a somewhat similar, but more simple method than this; it consists in determining, by any given method, the capacity of the skull in cubic inches, multiplying this by the weight of a cubic inch of water, and correcting for the difference between the specific gravities of brain and water, we have, as in the other case, cubic contents converted into brain weight.† The method proposed by Prof. Treadwell has an advantage in the fact that the weight of a cubic inch of water (252.5 grains, or 16.4 grams) has been determined with great accuracy, and is a constant quantity; while that of a cubic inch of sand varies according to locality, requiring a fresh determination each time a different kind of sand is used.

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* Extracted from the *Proceedings of the Boston Nat. Hist. Soc.*, vol. xi, 1868.

† *Philos. Trans. of the Royal Society of London*, 1836, p. 497.

The nature of the material used for measuring the capacity of the skull is important, but observers have had recourse to very different kinds. Water would unquestionably be the best, but its use is impracticable owing to the great difficulty in making the cranium sufficiently tight to retain it. The late Dr. Samuel George Morton, having used white mustard seed "on account of its spherical form, its hardness, and the equal size of its grains," afterwards, at the suggestion of Mr. J. S. Phillips, substituted No. 8 shot, which he found to give much more precise results, and with these all the measurements recorded in his tables were made.‡ Sir William Hamilton sharply criticises Dr. Morton's method as "only a clumsy and unsatisfactory imitation of mine," asserting that "pure silicious sand was the best means of accomplishing the purpose, from its suitable ponderosity, incompressibility, equality of weight in all weathers, and tenuity."§ Dr. J. Barnard Davis, whose practical knowledge of the subject makes his opinion worthy of high consideration, also recommends the use of fine sand,‖ but instead of measuring he weighs the quantity the skull holds. Having ascertained the cubic measure of an ounce of sand, the whole quantity is readily converted into cubic inches, or, by making a correction for difference in specific gravity, into brain weight. Various other substances, such as peas, flaxseed, rice, &c., have been used. Welcker recommends the grains of husked wheat. For a full account of these and of the different methods of comparing crania, the reader is referred to the valuable and instructive memoir of Dr. J. Aitkin Meigs, on the Mensuration of the Human Skull.¶

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* *Lectures on Metaphysics and Logic.* Edinburgh, 1860. Vol. i, p. 240.

† *American Journal of Medical Science,* in the account of the last illness of the Hon. Daniel Webster. January, 1853.

‡ *Crania Americana,* p. 253.

§ *Op. cit.,* vol. i, 1240.

‖ *Crania Britannica.*

¶ *North American Med.-Chirur. Review,* September, 1861, p. 837.

From the following table, the result of careful comparative experiments, it will be seen that, for exactness, shot are far preferable to sand, and that Sir William Hamilton's criticisms are unjust. The chief requisites for a good material for measuring crania, are lightness and uniformity in the size of the particles or component bodies; the size should be such that they will not escape from the foramina in the orbit, and their shape such that they will occupy the smallest compass with the least amount of shaking or compression. All these conditions were very nearly found in peas, and, with the exception of lightness, were realised in shot, the diameter in the second case being about 0.18 inch, and in the first 0.23 to 0.25 inch. Shot have the advantage over all other materials in their spherical shape, but their weight is such that fragile crania would be destroyed by them, though they may be safely used with those of ordinary strength. A skull having a capacity of ninety cubic inches when filled with shot weighs more than twenty pounds, which is altogether too heavy a mass to handle when many crania are to be examined.

With the view of determining the relative value of different materials, one and the same skull was measured eight times with each of the different kinds mentioned at the head of the columns of the table. The cranium was filled with a given material, which was well shaken down and compressed until no more could be received. The contents were then poured into a measure, care being taken that this should be done in each case at a uniform rate, but *without* being afterwards shaken or pressed down. The measure used was a litre, and the measurements are noted in cubic centimeters.

	Peas.	Shot.	Beans.	Rice.	Flaxseed.	Coarse Sand.	Fine Sand.
1	1190	1200	1210	1220	1250	1250	1315
2	1190	1205	1210	1222	1250	1260	1320
3	1190	1205	1210	1220	1240	1250	1290
4	1195	1200	1205	1220	1255	1260	1290
5	1198	1200	1210	1215	1250	1270	1320
6	1190	1200	1200	1220	1250	1250	1290
7	1195	1200	1205	1225	1240	1260	1350
8	1196	1205	1200	1220	1245	1260	1330
Average.	1193	1201·8	1206·2	1220·2	1247·5	1257·5	1313
Range.	8	5	10	10	15	20	60

From this table, it will be seen that the skull being carefully filled in each case, its capacity apparently varied according to the different substances used in the measurement; with peas it was 1193 c. c. and with fine sand 1313 c. c., or 120 c. c. more. This difference depends upon the fact that the substances used, under similar circumstances, adjust themselves to the least space with different degrees of facility. Shot and peas having a spherical shape, the position in which they happen to fall is a matter of indifference, since all their diameters are equal. The other bodies, whose diameters are unequal, require more or less of shaking and pressure in order that they may be packed in the smallest compass and thus an exaggeration of the capacity avoided. With proper care correct measurements can of course be made with either of the materials mentioned in the table, and in practice no one would omit to shake down and compress the material in the measure to the same degree that he would in the skull. The object of the table is only to show the comparative amount of compression and adjustment required. To present the subject in another way, if a litre is filled with peas, and then shaken, it will diminish one per cent. in bulk, while, under similar circumstances, coarse sand diminishes fifteen per cent. In the first case the error will not exceed one per cent.; in the second it may be, unless great care is taken, much more. Of the different substances used, peas and shot, on account of their spherical shape, give the best results, and coarse and fine sand the worst, on account of the irregular shape of the grains, the small size of these, for the finer the material the greater the error, and the roughness of their surfaces. As to peas and shot, the last give the most accurate and uniform results, while the latter, being less perfect spheres, lead to a slight error, but have the advantage of lightness, thus making manipulation, more easy. Sand has the further disadvantage of filling many angles, canals, and foramina not occupied by brain, and therefore of exaggerating the quantity of this last, and in requiring that the foramina in the orbit should be plugged to prevent its escape. This last objection is of little moment when a single skull is to be measured, but is considerable when the number is large. By using bodies of the size of peas or shot, the inconvenience and the exaggeration are both avoided. The difference in the table between the amount obtained by measuring with peas and shot depends upon difference in the size of the two latter.

There is still another step to be taken, even if an exact measurement of the cranium has been made. The brain, as already stated, does not fill the cranial cavity; a space, variously estimated, is occupied by the membranes and the vessels, which should be deducted from the general internal capacity. Welcker estimates this at from 11.6 to 14 per cent. of the whole cavity, according as the skull varies in size. Dr. J. Barnard Davis makes a correction of 10 per cent.

Brain, not cranial measurement, is, of course, the object of the study of the capacity of the skull; but until some definite results are obtained, which will enable the observer to make accurate corrections, we must remain content with cranial measurement for the present, and apply the corrections hereafter.

If we set aside shot as not well adapted to the purpose of measurement on account of their weight, a material suitable for equally accurate measurement is still a desideratum. Peas are not of a uniform size, though by sifting, uniformity may be approached, and there is a certain amount of error growing out of their want of sphericity, though this is quite small. Spheres of porcelain of the size indicated above, and still better of aluminium, on account of its lightness, would give the require qualities for accurate measurement.

The results obtained by various observers in making comparative measurements of crania point to one of the following methods as the most desirable.

I. *a.* Fill the skull and *weigh* the contained material.
  b. Convert weight of material into cubic measurement by determining the cubic measurement of a gram or an ounce of material, and multiplying this by the whole number of grams or ounces. With proper tables, this would be a quick and easy process, but otherwise a tedious one.
  c. Convert weight of material into brain weight by correcting for difference in specific gravity.

II. *a.* Fill the skull and *measure* the contained material.
  b. Convert cubic contents into brain weight by multiplying the number of cubic inches by the weight of a cubic inch of water (252.5 grains), or the number of cubic centimeters by the weight of a cubic centimeter of water (one gram), and allowing four per cent. for the difference of the specific gravities of brain and water.

The second has the advantage of being the more simple process, and requires the fewest steps, while the first has the advantage in weighing, which is a somewhat more accurate method than measuring. The weight, however, must be converted into cubic measure, if we compare skulls by their cubic contents. With care, either of them is sufficiently correct, and in his choice the observer can and will be guided by his likings.